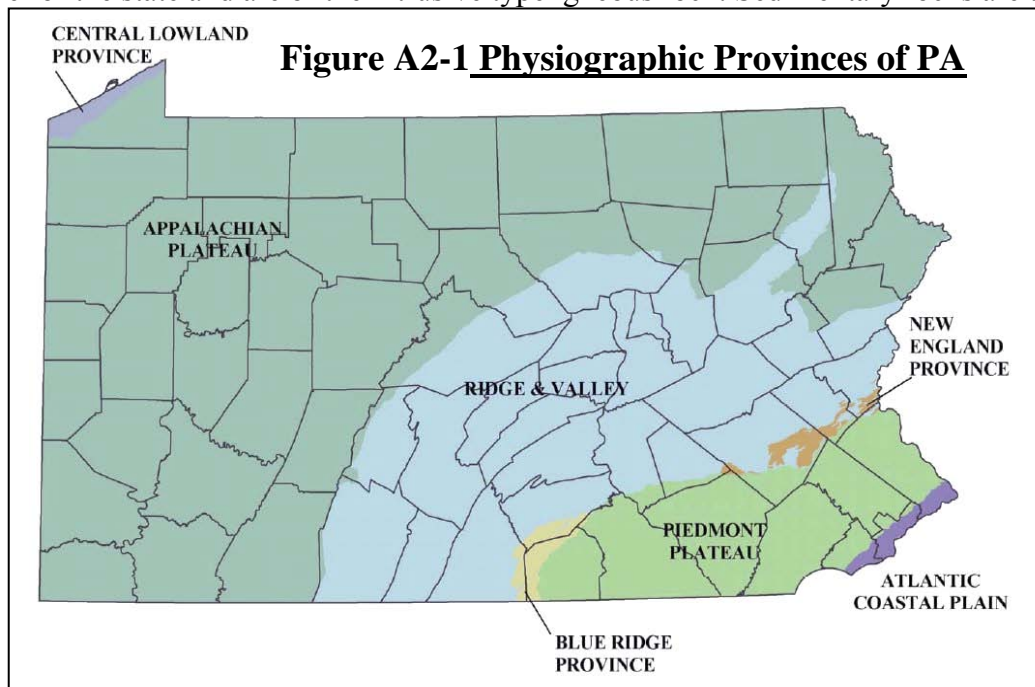


APPENDIX 2. Case Study: Pennsylvania's Geology

Geologists have divided Pennsylvania into seven physiographic provinces (see Figure A2-1). Each province has a vastly different geological history that has influenced the local geology and shaped the landscape. In general, older rocks (more than 570 million years old) are found in southeastern Pennsylvania while younger rocks (less than 290 million years old) are found in the northwest parts of the state.

Thus, most of the igneous rocks in Pennsylvania are found in the southeastern corner of the state and are of the intrusive type igneous rock. Sedimentary rocks are the



most common type of rock in Pennsylvania and cover approximately 85 to 90% of the state. Metamorphic rocks are again present predominantly in the southeastern portion of the state.

Surface water was a major factor in shaping the landscape in all seven provinces, eroding and carving most of the river and stream valleys that can be seen today. The periods of glaciation occurring in northern Pennsylvania also altered the landscape. The following province descriptions provide a basic overview of Pennsylvania's landscape and its geologic history.

A2.1 Central Lowland Province. This is the northern most province in Pennsylvania, and is found along the Lake Erie shoreline in Erie County. This is only a small portion of the Central Lowland Province as it extends from northwestern Pennsylvania and western New York, northwestward to Minnesota and southwestward to Texas. The portion of the province located in Pennsylvania consists of a series of sand and gravel beach ridges that run parallel to Lake Erie. These ridges were formed by the lake during the last period of glaciation in the area, from approximately 24,000 to 18,000 years ago. As the glaciers retreated and melted, water levels in Lake Erie were higher than they are today. Waves piled up sands and gravels, forming these beach ridges at the then current water levels. As the lake's water levels declined, these beach ridges became inactive, with vegetation becoming established and stabilizing the mobile sand ridges. The ridges can now be viewed as the gently rolling land that is characteristic of the area. Additional wave [erosion](#) and relatively steady water levels have caused the more recent formation of a bluff along the Lake Erie shoreline. Surface water drains towards the lake in this area, forming steep-sided, narrow valleys that cut across the ridges and into the underlying shales and siltstones. Rocks in this province include gray and black shale, red sandstone, limestone, and chert.

A2.2 Appalachian Plateaus Province. This province covers the greatest part of Pennsylvania, approximately 60% of the state, including 42 counties and extends from Greene, Somerset, and Fayette counties in the southwest to Erie in the northwest and northeastward across the northern part of the state to Wayne and Pike counties. The province was covered by a series of salt and fresh water seas in which [sedimentation](#) occurred. [Sediments](#) laid down by these seas became cemented together, forming the 250- to 405-million-year-old sedimentary rocks that underlie this area. During periods when the land was not submerged, vast swamps and bogs developed. Dead vegetation from these swamps and bogs accumulated and formed thick beds of peat. Some of these peat beds were later covered by new layers of [sediment](#), which compressed the peat and caused it to metamorphose into coal, forming the vast coal deposits that have played an essential part in Pennsylvania's history. Surface water [erosion](#) has deeply carved an extensive drainage network across this province. Glaciers covered a large portion of the northern corners of the state, where they dramatically reshaped the landscape. Rocks in this province include red, gray and black shale, red and gray sandstone, limestone, conglomerate, coal, and chert.

A2.3 Ridge and Valley Province. The Ridge and Valley Province of central Pennsylvania is characterized by long, narrow mountain ridges separated by valleys of varying widths. This province encompasses approximately a quarter of the state and extends northeastward into New Jersey and southwestward through Maryland. The province is underlain by the many of same sedimentary rocks that underlie the Appalachian Plateaus Province and are approximately 290 to 570 million years old. The subsequent geological events, however, warrant separation of this area into a new physiographic province.

The earth's continental plates drift around the surface of the earth at a rate of about an inch per year, and about 290 million years ago, North America collided with Africa. This collision resulted in a period of mountain building as the two continents pushed together. The massive forces involved with this collision caused the relatively flat rocks within the province to wrinkle and become folded much like a carpet does when the ends are pushed together. This geologic upheaval resulted in the formation of a mountain range that was 150 miles wide and at least 2.5 miles high that is referred to as the Alleghanian Mountains. Approximately 250 million years ago, the Alleghenian Mountains began to erode away. Because some rocks are more susceptible to [erosion](#) than others, [erosion](#) rates differ. Extensive [erosion](#) of these mountains has since formed valleys in areas of soft rock (shales and siltstones) and left erosion-resistant ridges comprised of very tough sandstone. The ridges and valleys presently cutting across the state are all that remain of this former mountain range. Rocks in this province include gray and black shale, siltstone, red and gray sandstone, limestone, chert conglomerate, quartzite, and dolomite.

As with the Appalachian Plateaus Province, surface water [erosion](#) has played a major role in shaping the current [topography](#) of the province. The Susquehanna River, which cuts through many of the ridges of the province, is evidence of the impact of surface water [erosion](#) on shaping the landscape. The Susquehanna River was able to erode sufficient material to maintain its course while the underlying land was being uplifted by the collision of the continental plates. Glaciers have also acted on small portions of the province, primarily in Northampton, Carbon, Monroe, Luzerne, Columbia, Sullivan and Lycoming counties.

A2.4 Blue Ridge Province. The Blue Ridge Province is represented in south-central Pennsylvania in portions of Cumberland, York, Adams, and Franklin counties. Known locally as South Mountain, this mountain ridge extends southwestward into Maryland and Virginia, where it is known as the Blue Ridge Mountains. The quartzite and metamorphic volcanic rocks that make up this highland province are [erosion](#) resistant and more than 500 million years old. Rocks in this province include shale, sandstone, limestone, quartzite, dolomite, gneiss, granite, marble, and other metamorphic rocks.

A2.5 New England Province. The portion of this province extends southwestward into portions of Northampton, Bucks, Lehigh, Berks, Lancaster, and Lebanon counties in southeastern Pennsylvania. This portion of the province is known as the Reading Prong section, which consists of highly distorted metamorphic rocks that are

significantly more resistant to [erosion](#) than the surrounding sedimentary rocks. Rocks in this province include gneiss, marble, other metamorphic rocks, and granite.

A2.6 Piedmont Province. The Piedmont Province is located in Southeastern Pennsylvania and covers approximately 15% of the state. This area was influenced tremendously by the same collision of continental plates previously discussed and again formed the Alleghanian Mountains in this area. This mountain building process created metamorphic rocks that are at least 430 million years old. Younger sedimentary rocks containing intrusions of igneous rock formed in the northern portions of the province approximately 140 to 250 million years ago during the separation of the two continental plates. As with the Ridge and Valley Province, millions of years of surface water [erosion](#) has worn down the grand Alleghanian mountains to form the current [topography](#) characterized by broad valleys and gently rolling hills. Rocks in this province include quartzite, schist, slate, marble, serpentine, gneiss, other metamorphic rocks, red sandstone, shale conglomerate, limestone, dolomite, diabase, and granite.

A2.7 Atlantic Coastal Plain Province. This province is located in the extreme southeastern part of Pennsylvania, including almost all of Philadelphia County and southeastern portions of Bucks and Delaware counties. This province extends from Massachusetts to Florida, and includes most of Delaware and all of southern New Jersey. In higher elevations within this province (maximum elevation is about 200 feet above sea level), sand and gravels approximately 2 to 67 million years old overlie older metamorphic rocks. In lower elevations along the Delaware River, floodplain deposits of sand, gravel, silt, and clay are less than 2 million years old. In general, the geologic history of the province has produced rather flat lands with sandy soils. Many of the sand, gravel, silt, and clay deposits remain unconsolidated, as they have not had sufficient time to become cemented together.

A2.8 What Pennsylvania Has to Work With. These previous descriptions of Pennsylvania's geologic history with its physiographic provinces show what the local governments have to work with as far as rocks, soils and road materials. Comparing the province map with the geology map and a soils map shows the similar patterns (Figure A2-2 and Figure A2-3). And, of course, the soils will dictate types and growth of vegetation and the environment in which the roads exist. It explains why many unpaved roads through most of Pennsylvania use limestone as the aggregate road material available from local quarries. It also explains the lack of limestone across the north central part of the state where only softer shales are available, creating more problems of [erosion](#) and [dust](#) along with increased road maintenance. Geologic history shows how the steep hills and deep valleys in some sections were formed. Roads and banks in these sections are difficult to stabilize because they must fight gravity's relentless force. Pennsylvania still has approximately 20,000 miles of unpaved roads. [Sediment](#) and [erosion](#) from these roads represent major environmental problems. Part of Pennsylvania's rich geological legacy is its vast resources of coal. But this bounty has come at a price. Acid mine drainage into the streams costs taxpayers millions of dollars each year in cleanup expenses.

Figure A2-2: What do you have to work with?

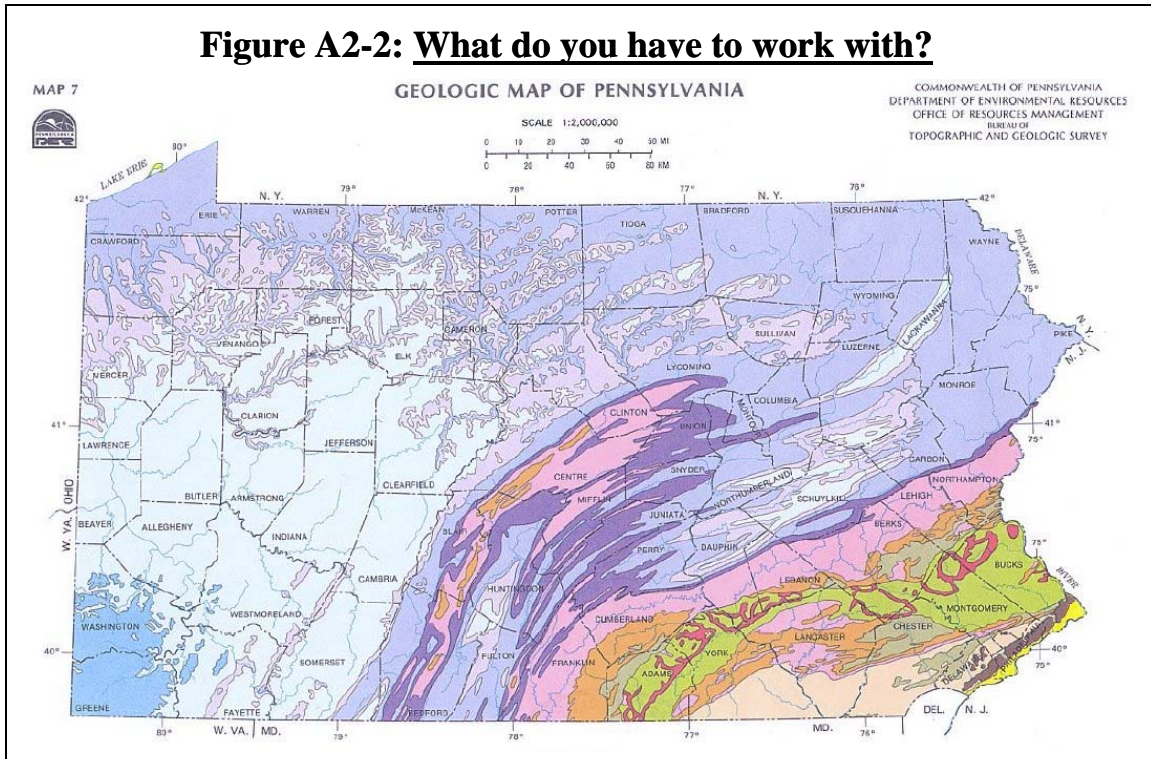


Figure A2-3: What do you have to work with?

